REPORT 13212 E

Optimal protection of parking decks at new construction and renovation Stage I-IV

Swedish Cement and Concrete Research Institute

Optimal protection of parking decks for new construction and renovation Stage I-IV – Surface coating systems

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Content

Summary

Swedish Cement and Concrete Research Institute and Swerea KIMAB, together with a number of manufacturers, contractors and property owners, completed the current project with partial funding from SBUF. Financial support for the project was also received from Rebet, NFB (Norwegian Association for Concrete Rehabilitation) and Ångpanneföreningen Research Foundation. In this report, all four stages, from Stage I (2013) to Stage IV (2016), are summarized with respect to work carried out on coating systems intended for use on concrete parking decks.

The aim of the project, as a whole, was to develop a basis for how a parking deck should be designed (with respect to the coating and cathodic protection), and how it should be protected and maintained in an optimal and economical manner. New requirements specifications and guidelines, including a new laboratory method for testing the resistance to studded tyres (resistance to scuffing), were developed for coating systems intended for use on concrete parking decks. A guideline for cathodic protection in parking garages was developed as well.

Test fields with some 20 different types of coating systems were placed in three different garages in Gothenburg, Stockholm and Linköping respectively. The test areas are followed up, primarily for wear. In connection to the placing of test fields, test slabs were coated for testing of wear resistance in the laboratory. The test field installations have been presented in the past three SBUF reports 12764, 12936 and 13084 respectively. They have all been followed up.

Laboratory test results according to the resistance to scuffing method (modified prEN 12697-50) show large differences between the various products. The correspondence between individual test slabs seems good, but neither the repeatability nor reproducibility has yet been defined for the current method. Test period, initially in the project was 210 minutes, but was reduced to 60 minutes in a draft method description as the total wear after a longer test period may also include concrete wear, and thus can be misleading. Wear on the studded tyres (in the equipment) seems low and is not expected to have affected the test results significantly. The method differentiates well between different products. When compared with the corresponding test results according to Prall (EN 12697-16), it is stated that these results also differ widely between products. The two methods do not correlate with each other but show various types of wear. The methods also rank various products differently. Testing according to RWA (EN 13892) was performed for some of the coating systems, but has since Stage II of the project not been used, partly because of mismatches between individual test slabs.

During Stage IV, guidelines and specifications for the protective coating systems have been developed, including a so-called Excel-application which is intended as a support tool in the selection of appropriate coating system for a specific garage. These are included as appendices to the Swedish and more comprehensive version of this report.

1 Background

Parking garages belong to the most exposed type of concrete construction, especially when it comes to corrosion of reinforcing steel. Damage to the concrete occurs mainly due to chlorides from road salt as cars enter the facility in the winter. During dry weather conditions the water that was brought into the garage then dries away while the chlorides remain and chloride concentrations in the concrete thus increase progressively. The concrete around the corroding reinforcement deteriorates due to the formation of rust. This results in an increase in volume compared with the original steel. This swelling pressures cause cracking and spalling of the concrete. Even chlorides already embedded in the concrete occur. Corrosion of reinforcement is a serious issue because the strength of the structure can be reduced and the extent of damage is not always visible during external inspections [1].

According to CBI experience, damage in the form of corroding steel reinforcement in various types of car parks and garages arises mainly in floors, ramps and in the lower parts of walls and pillars. This type of damage can be largely avoided by using the right concrete quality, sufficiently concrete cover thickness and, not least, a well-functioning surface protection system. Another possible measure is, to a greater or lesser extent, also use cathodic protection in connection with repair or even for new construction [2]. Well-functioning surface protection systems in combination with cathodic protection at critical places in a garage are considered to be a successful and cost-effective concept for the protection of concrete in parking facilities. These two protection methods have therefore been raised for the development and evaluation of the current project as a whole.

The project started in 2013 and is now completed in four different stages. In this report, all four stages are summarized for coating systems only. For more detailed information on laboratory tests, test facilities and follow-up of coating systems as well as installation and monitoring of cathodic protection, reference is made to the previous reports in the project [3], [4] & [5].

1.1 Coating systems

The three main types of protective coating for parking decks are plastic-based coating systems, bitumen-based systems or hard concrete / cement-based systems.

1.1.1 Plastic based coating systems

In general, a plastic-based coating system includes synthetic resin of some kind applied in several layers, including aggregate materials such as sand / minerals and fillers. If a membrane is included in the system, this comprises a flexible, waterproof and crack-bridging layer. Sometimes the membrane is coloured and is then expected to serve as an indication layer on abrasion. The wear layer part of the system often contains a lot of sand / mineral and filler. Large amount of filler limits the wearing course elasticity and makes the material harder. To obtain more coarse structures and improved slip resistance, sand / minerals can be applied over the placed plastic mass. For higher wear resistance (in curves and ramps), granite or bauxite (aluminum containing black sand / minerals) are used. On top of the wear layer, a thin topcoat is often applied. See Figure 1.1.

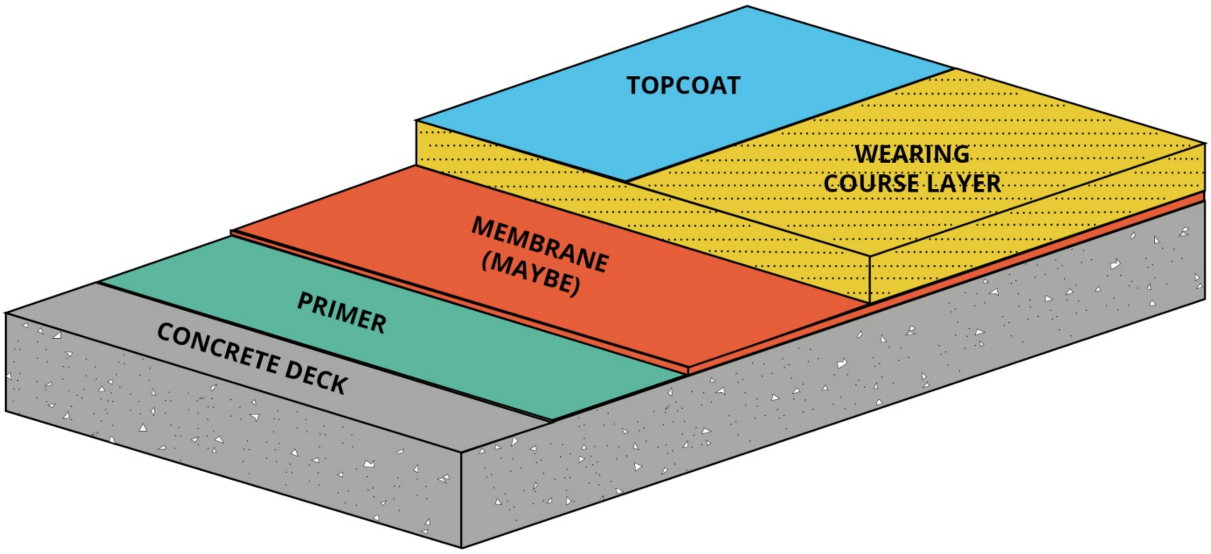


Figure 1.1 Example of plastic-based coating system of several layers [3]

1.1.2 Bitumen-based coating system

A bitumen-based coating system usually is mastic asphalt in combination with a waterproofing sheet which is SBS (styrene butadiene styrene) -modified with polyester reinforcement and polymer bitumen on both sides. The thickness of the sheet is 4-5 mm and it is torch-welded in most cases to the primed concrete substrate. The primer may consist of bitumen solvent, bitumen emulsion or acrylate (MMA, i.e. methylmethacrylate). The wearing course layer as such consists of polymer modified coarse aggregate mastic asphalt. The polymer content in the mastic asphalt is approximately 4 % by weight of the binder. Flow improving wax additives are optionally added to lower the mixing and placing temperature, thus improving the working environment associated with smoke exposure, as well as the environment from a broader perspective. The waterproofing sheet may sometimes be replaced with fine aggregate mastic asphalt consisting of polymer modified bitumen, filler and sand. The mastic is placed approximately 10 mm thick on a ventilating net.

1.1.3 Cementitious coating system

Hard concrete is made with cement as a binder and may be reinforced with ballast and fibers such as acrylic or epoxy. The thickness varies from about 5 to 50 mm. As a rule, the coating is placed on water treated concrete surface after primer treatment.

1.1.4 Damages

Damage to plastic-based coating systems occurs mainly in the form of wear, cracking and adhesion loss. Sink marks may occur in mastic asphalt during prolonged heavy point loads (e.g. a motorcycle leaning on its support). Examples of damage to the mastic asphalt or plastic-based coating are shown in Figure 1.2. As for hard concrete of various kinds, concrete shrinkage may cause cracking.

1.1.5 Wear resistance

Regarding wear resistance, coating systems are exposed to studded tyre wear in Swedish / Scandinavian car parks, which is not the case in most other countries. This must be considered when selecting the coating and, not least, test method for determining (predicting) wear resistance in the laboratory. Resistance to chlorides and other chemicals that may occur on a parking deck is another important feature that must be reported. A relevant and for parking decks suitable specification for surface coating systems should be developed to facilitate for clients as well as manufacturers and entrepreneurs in their choice of products. The determination of wear resistance is a key factor.

Figure 1.2 Example of damage in the form of sink marks for mastic asphalt (left hand side) and wear for plastic-based systems (right hand side)

1.1.6 Thicknesses and cost

The total thickness of plastic-based surface coating systems varies as a rule between about 3 and 8 mm, depending on the wearing layer thickness and if membrane is included in the system or not. Material costs for a coating system vary of course and also depend on the system design and layer thicknesses. According to information from various providers, the price (2012) lies between 150 and 350 SEK / m² (excluding membrane). The membrane can cost an additional 150-250 SEK / m². Other charges may apply, for example, for UV-resistant topcoats. With polyurea, the cost is reportedly to be about 400 SEK / m^2 for 2 mm, approximately 550 SEK / m^2 for 4 mm and approximately SEK 750-800 / m^2 for ramps. The contractor placing costs (which of course also apply) may be higher for some of the systems. According to GAFS (Swedish mastic asphalt association) completed total work including bitumen primer, waterproofing sheet and 30 mm PGJA costs about 400 SEK / m² for a (black) coating system. Total work on e.g. hard concrete product Intercrete is about 300 SEK / m^2. (including blasting of the concrete surface).

1.1.7 Life span

The life span of the surface coating system depends on a number of factors, in addition to coating thickness, choice of materials and a successful performance. Traffic loads and ambient conditions (temperature, chemical load, etc.) have obvious importance as well as maintenance and repair. The estimated life span, according to the manufacturer's data, is between 8 and 30 years for plastic-based systems, however, as a rule, based on the experience of other European countries without the use of studded tyres. The thickness is crucial. The life of a sheet and mastic asphalt system should be at least 30 years in Swedish conditions. A successfully placed hard concrete, according to the manufacturer, also last for at least 30 years. For all cases, the coating must be regularly inspected and maintained appropriately.

Life cycle costs have not been included in the project.

1.2 Purpose of the project

There are currently no clear guidelines for the choice of protective coating (or cathodic protection) in parking garages. The purpose of the project as a whole has therefore been to develop a basis for how a parking deck should be designed (with respect to the coating and cathodic protection), be protected and maintained in an optimal and economical manner. Draft guidelines and specifications have been developed as well as a client's support tool in the selection of coating systems.

The overall project was planned initially to extend over at least a three-year period, and has so far lasted for four years (2013-2016). Follow-ups of test fields and installations are proposed to continue for several more years.

1.3 Benefits

A well-functioning waterproofing and protection coating system, maybe in combination with cathodic protection at critical sites in a parking facility, will contribute to a more sustainable system. A longer technical lifetime without costly concrete repairs with less damage and less maintenance will be the result. This describes the major benefits of the project. For parking decks with no protection, however, the degradation may progress rapidly with significant repair costs to follow. This also applies to parking decks with inadequate or even inappropriate waterproofing coating that cannot withstand the environment and traffic load appearing on the site.

Entrepreneurs and material manufacturers thus are expected to deliver better and more sustainable facilities for managers and property owners. This in turn can lower their maintenance costs and they need not be faced with the choice of possibly having to reduce maintenance efforts, resulting in a shorter life for the car parking facility.

The level of knowledge is raised among clients as well as manufacturers and contractors in terms of materials, specification and evaluation of functional properties.

2 Implementation of the project - Coatings and Concrete

Detailed practical planning of the project was carried out by CBI together with manufacturers and entrepreneurs, starting at the beginning of Stage I. Literature research and the collection of experience data was based on CBI report 1: 2012, and the experience of managers and owners of parking facilities [6].

Stage I (2013) included:

- project planning and selection of parking garages
- placing of test areas in Kville
- testing of modified laboratory methodology in Aachen [7]

Stage II (2014) included:

- placing of test areas in Åkeshov, plus concrete analysis
- laboratory testing of wear resistance to studded tyres (according to three methods). Test slabs from Kville and test slabs from Åkeshov

Stage III (2015) included:

- placing of test areas in Linköping (Baggen) plus concrete analysis
- laboratory testing of wear resistance to studded tyres (according to two methods). Test slabs from Baggen
- follow-up of test areas
- follow-up of older surface coating systems (master thesis)
- specification and guidelines

Stage IV (2016) finally included:

- specification and guidelines
- support tool
- follow-up of test areas

Test installations, follow-up and results from laboratory testing of wear resistance are summarized in the following sections (2.1-2.3).

2.1 Placing of test areas in parking garages

Placing of waterproofing and protection coating system on concrete was carried out, as already mentioned, in three different garages.

- Kville in Gothenburg during November 2013
- Åkeshov in Stockholm during August 2014
- Baggen in Linköping during July 2015

Initially, the whole test section in the respective garage was sandblasted (Kville and Åkeshov) or polished (Baggen). Each test area is approximately 30-35 square meters.

Concrete analysis was conducted within the project for Åkeshov and Baggen. The results show that the concrete is of high quality in both garages. The values of compression strength also show that the concrete is very dense. No damage mechanisms could be observed on the concrete in the respective garages where tested. The carbonation depth was small. In Kville, the concrete status had been assessed by WSP, 2012. For more details regarding the concrete analysis earlier SBUF reports are referred to.

Concrete test slabs were applied with respective coating systems adjacent to each placing of test areas, and tested in the laboratory with respect to wear resistance to studded tyres. (See previous SBUF reports in Swedish). Concrete test slabs were also pre-treated in the same way as the support on site.

The different test areas/sites are described briefly in the following three sections. For more detailed information, please refer to previous SBUF reports (in Swedish).

2.1.1 Kville 2013 – nine test areas and coating systems

Product systems and producers / entrepreneurs who took part in the placing of test areas at the parking garage in Kville are shown in Table 2.1. Completed total test area is shown in Figure 2.1. The parking deck is located at a middle level in a cold garage for residential parking.

Table 2.1 Product systems and manufacturers/entrepreneurs who took part in the placing of test areas in Kville

Area no	Type of product	Product name	Thickness (mm)	Manufacturer/ entrepreneur
1	Mastic asphalt	**PGJA 8** with wax bitumen sheet according to TRVKB10 and bitumenprimer	30	Duo Asfalt/GAFS
2	Hard concrete	**Densit** with Densit primer (cementitious)	8-12	Spännbalkkonsult SBK
3	Polyurethane	**Sikafloor 375** with topcoat and epoxy primer	3-8	Sika
4	Polyurethane	**StoCretec Metod 1007** with topcoat and epoxy primer	3-8	Sto
5	Polyurethane	**Deckshield ID** with topcoat and epoxiprimer	3-8	Flowcrete
6	Polyurethane	**Conideckk 2255** with topcoat and epoxy primer	3-8	Modern Betong
7	Acrylic and polymer	**Map Pro** Flexibinder with top coat and epoxy primer	3-8	Mapei
8	Polyurea	**Micorea S3** with epoxy primer	3-8	Elmico
9	Polyurethane	**Mapefloor PU** Flexibinder with topcoat of polyurethane and MMA-primer	3-8	Mapei

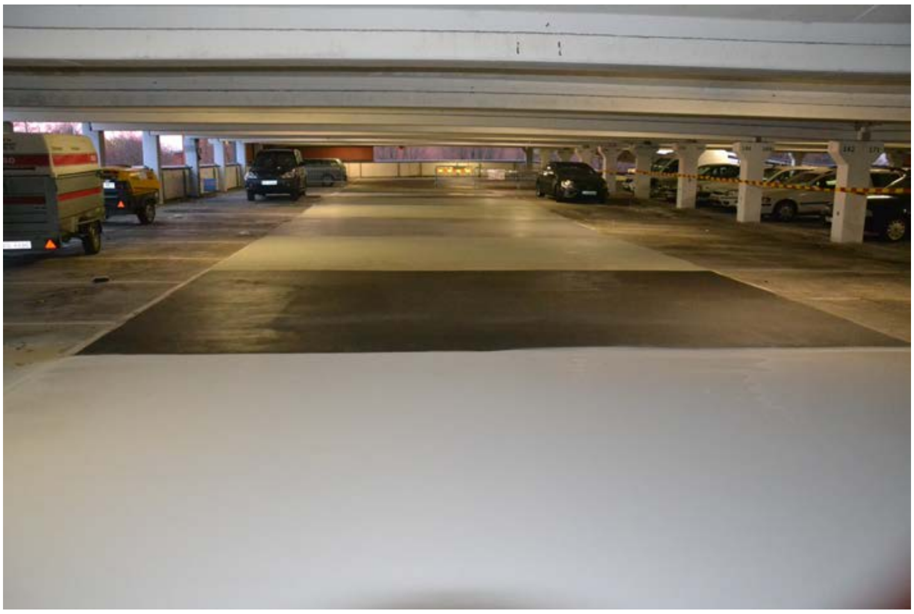


Figure 2.1 Completed total test area with nine coating systems - Kville 2013 (Photo: Y Edwards)

2.1.2 Åkeshov 2014 – seven test areas and coating systems

Product systems and producers / entrepreneurs who took part in the placing of test areas at the parking garage in Åkeshov are shown in Table 2.2. Completed total test area is shown in Figure 2.2. The parking deck is at ground level close to the Åkeshov swimming hall facilities.

Table 2.2 Product system and manufacturers/entrepreneurs who took part in the placing of test areas in Åkshov

Area no	Type of product	Product name	Thickness (mm)	Manufacturer/ entrepreneur
1	Hard concrete	Intercrete	More than 2	International/ Akzo Nobel/ TPM
2	Acrylic	Silikal	3-8	Acrylgolv Industrigolv
3	Acrylic	Duracon	3-8	Flowcrete / Injo Golv
4	Polyurethane	Ucrete	3-8	Modern betong
5	Hard concrete	Mastertop	about 20	Modern betong
6	Epoxy	Micopox C HD	3-8	Elmico/Lingfjords
7	Polyurea	Micorea S3 med epoxy primer	3-8	Elmico/ Lingfjords

Figure 2.2 Completed total test area with seven coating systems - Åkeshov 2014 (Photo: Y Edwards)

2.1.3 Baggen 2015 – six test areas and coating systems

Product systems and producers / entrepreneurs who took part in the placing of test areas at the parking garage in Baggen are shown in Table 2.3. Completed total test area is shown in Figure 2.3. The parking deck is outdoors on level five. Baggen is located very centrally in Linköping with a total of 400 parking spaces.

Tabell 2.3 Product system and manufacturers/entrepreneurs who took part in the placing of test areas in Baggen

Area no	Type of product	Product name	Thickness (mm)	Manufacturer/ entrepreneur
1	Polyurea	Purtop 1000	3-4	Mapei/Polyterm
2	Acrylic	Silikal Struktur	about 4	Industrigolv
3	Mastic asphalt	PGJA 11	about 30	GAFS/Haninge tak
4	Polyurea	Micorea HS	3-4	Elmico/Sprayskum
5	Hard concrete	Primer Sika MonoTop 910 Wearing course Sikafloor-1+Corcrete	8-10	Sika
6	Acrylic	Duracon	6	Flowcrete/ Pea fogfria golv

Figure 2.3 Completed total test area with six coating systems - Baggen 2015 (Photo: Y Edwards)

2.2 Follow-ups

All test fields were visually inspected during 2014- 2016. The following sections summarize these inspections generally.

2.2.1 Kville.

Follow-up of the nine test coating systems in Kville, with visual assessment and photographic documentation, was conducted in November 2014 and in May 2016. In general, it was noted that all test areas looked very good:

- no cracks
- no adhesion loss except at the edge of test area 8 (which was fixed between the two inspections)
- pits (test area 8 and 9)
- abrasion from studded tyres (marks on all test areas)

Marks after studs and pits are shown in Figure 2.4. For more detailed information, please refer to previous SBUF reports in Swedish.

Figure 2.4 Marks after studs on test area 5 (left hand side) and pits (right hand side) on test area 8 (Photo: Y Edwards)

2.2.2 Åkeshov

Follow-up of the seven test coating systems in Åkeshov, with visual assessment and photographic documentation, was conducted in November 2015 and in August 2016. In general, it was noted:

- no cracks, but noticeable crazing on test area 5 (Mastertop)
- no adhesion loss
- pits (a few on test area 1, 2 and 7) and lots of pinholes down to the concrete on test area 6 (epoxy Micopox)
- abrasion from studded tyres (marks on all test areas but most noticeably on test area 6 and least on test area 7)

Crazing and pinholes are shown in Figure 2.5. For more detailed information, please refer to previous SBUF reports in Swedish.

Figure 2.5 Crazing (left hand side) on test area 5 (2016) and pinholes (right hand side) on test area 6 (2015) (Photo: Y Edwards)

2.2.3 Baggen

The first follow-up of the six test coating systems at Baggen, with visual assessment and photographic documentation, was conducted just a month after the placing of test areas. The next follow-up was in August 2016. In general, it was noted:

- no cracks, but minor damage on test area 5 (Sikafloor-1+Corecrete)
- no adhesion loss except at the edge of test area 4 (Micorea HS)
- pits, a few and blistering on test area 4 (Micorea HS)
- abrasion from studded tyres (marks on all test areas)

Crazing and adhesion loss are shown in Figure 2.6. For more detailed information, please refer to previous SBUF reports in Swedish.

Figure 2.6 Crazing/minor damage (left hand side) on test area 5 (2016) and adhesion loss (right hand side) on test area 4 (2016) (Photo: Y Edwards)

2.2.4 Older coating systems in garages

As a complementary part in Stage III of this project, a Master Thesis at KTH Building Technology and Design was included [8]. Nineteen coating systems including five different types of material were inspected in the Stockholm area. The purpose of the inspections was to identify damages and wear that had occurred over time for the coating systems. The report results in an analysis of the coating materials and the relationship between damage and wear of the different systems on ramps and intermediate parking deck floors. The inspected parking decks are made of concrete with coating systems of three type materials: plastics (acrylic, polyurethane and epoxy), mastic asphalt and hard concrete.

The inspection included visual assessment of damage and wear, including: cracking, crazing, adhesion loss, plastic deformation, abrasion from tyres, frost damage, holes, reinforcement corrosion, colour and gloss change, snow removal damage, marks from tyres and scratches caused by studded tyres.

The various coating systems are between 3 and 22 years old and therefore not directly comparable. An old system of 20 years naturally is assumed to be more damaged than a younger system of only 3 years. The same applies to traffic intensity, that is, a coating system subjected to high traffic intensity becomes damaged at an earlier stage than a coating system with low traffic. In order to make collected data for the various garages comparable, a formula was developed that modifies the graded amount of damage with respect to the intensity of traffic and system age. See the equation for the equivalent amount of damage below.

$$\frac{s}{å \cdot t} \cdot 100 = e$$

s = amount of damage [0-5], å = age of coating system [year], t = estimated traffic intensity [0-5], e = equivalent amount of damage. To make the equivalent amount of damage easier to grasp and comparable, the result value is multiplied by a factor of 100.

2.3 Testing of wear resistance

Testing was carried out according to the three laboratory methods listed below:

- Resistance to Scuffing, modified prEN 12697-50
- Prall, SS EN 12697-16
- RWA, SS EN38921

The modification of the Resistance to Scuffing test method consists primarily of fitting the equipment with studded tyres for the simulation of traffic with studded tyres in Swedish / Scandinavian garages. The equipment is shown in Figure 2.7.

Figure 2.7 Equipment for testing Scuffing resistance, with studded tyres (Photo: Y Edwards)

Testing according to RWA was performed for the coating systems in Kville and Åkeshov but was not included in the third test round due to poor repeatability of the method and lack of compliance with experience in the field.

This section summarizes only completed laboratory testing in accordance with Resistance to Scuffing for all coating systems included in the project as a whole. For other laboratory tests, please refer to previous SBUF reports (in Swedish).

The methods Scuffing Resistance and Prall do not correlate according to test results in this study, but show different types of wear. The methods rank the various products differently.

2.3.1 Scuffing Resistance with studded tyres

Figure 2.8 shows results obtained in terms of weight loss according to the Scuffing resistance test method for all systems. Only the type of product (concrete, PGJA, polyurethane, polyurea, acrylic or epoxy) is specified in the diagrams. With concrete, two different types of hard concrete are referred to. Acrylics also include hybrid products of acrylic-based type combined with polyurethane.

Testing with various long test periods shows that a period of 60 minutes is suitable for the method. Initially in the project, the test time was 210 minutes, but during the project it was reduced to 60 minutes in a draft method description as the wear after longer test periods also may include concrete wear, and thus be misleading.

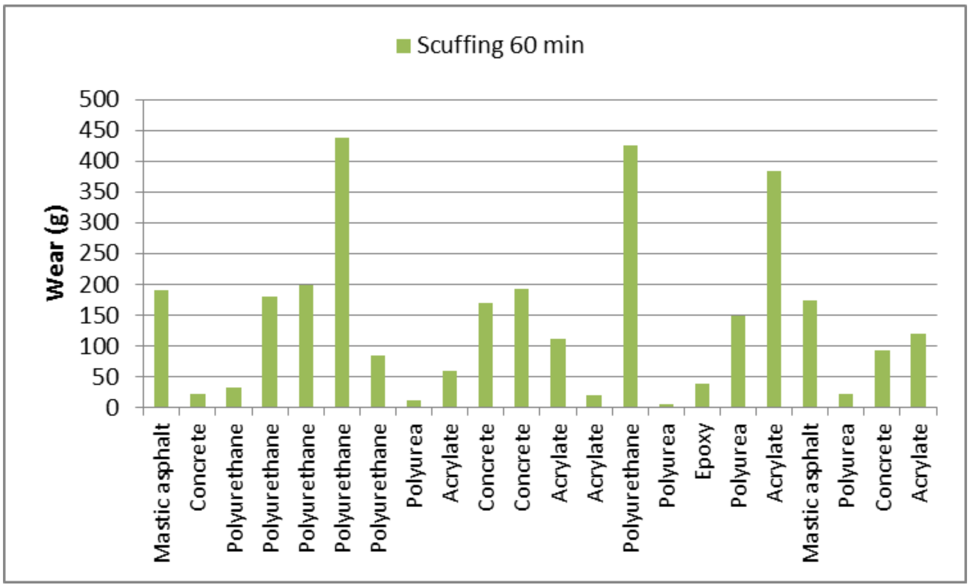


Figure 2.8 Scuffing – Wear expressed as weight loss in grams after 60 minutes (y-axis) at 20°C, all 22 systems. The systems are shown starting from the left in Kville (9 systems), Åkeshov (7 systems) and Baggen (6 systems)

The diagram in Figure 2.9 below shows obtained wear as reduction of thickness in mm.

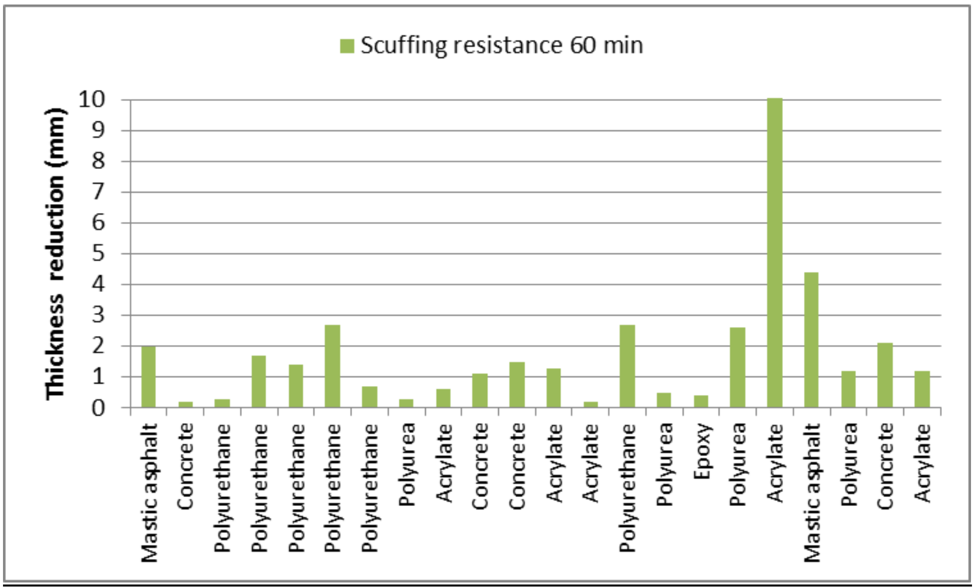
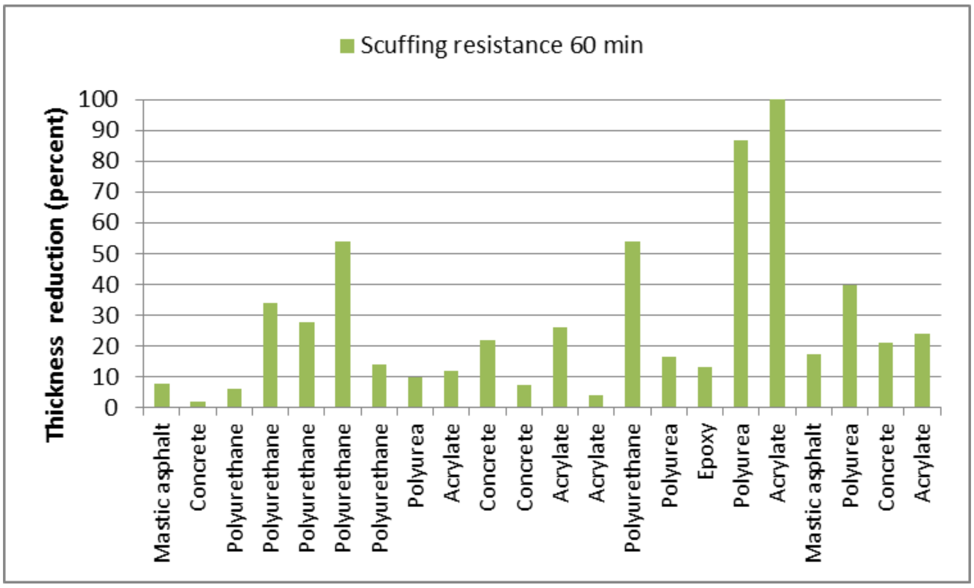


Figure 2.9 Scuffing – Wear expressed as thickness reduction in mm after 60 minutes at 20°C, all 22 systems. The systems are shown starting from the left in Kville (9 systems), Åkeshov (7 systems) and Baggen (6 systems)

The significance of the coating system thickness for the wear resistance over time (lifetime parameter) becomes clearer if wear is expressed in percentage of thickness reduction. Such results are shown in the corresponding diagram in Figure 2.10 below.



Figur 2.10 Scuffing – Wear in expressed as percentage of thickness reduction after 60 minutes at 20°C, all 22 systems. The systems are shown starting from the left in Kville (9 systems), Åkeshov (7 systems) and Baggen (6 systems)

Testing according Resistance to scuffing has thus been performed for a total of 22 different coating systems in Stage II and Stage III. The systems were applied to concrete slabs adjacent to the test-installations. Two test slabs were included for each coating system in terms of this particular method. Conclusions regarding the method are:

- the correlation between individual test slabs seems good, but the repeatability or reproducibility has not yet been fixed for the current method
- a test period of 60 minutes is proposed, which means 2460 wheel revolutions with studded tyres at a rate of about 1 km / h in the laboratory
- the wear of the studded tyres (used in the test equipment) seems low and is not expected to have affected the test results significantly
- the method differentiates clearly between the various products and shows large differences

2.4 Guidelines

Guidelines for waterproofing and protection coating systems to be used on concrete parking decks have been developed and are presented in Appendix A of the SBUF report 13212 (in Swedish).

The purpose of the guidelines is to raise awareness and point to various benefits, shortcomings and problems in the selection of coating systems. The document shall be read in conjunction with the Excel application, which has also been developed within the project as a support tool to the client (see section 2.5 below).

In the guidelines, various standards and regulations that should be known within the area are listed and a proposal on the functional requirements for coating systems on parking decks of concrete is presented. Different types of product and systems are addressed in terms of content, structure and function. Advantages and disadvantages are listed. Finally, workmanship and health and safety are treated.

2.5 Client’s support tool

A support tool for the client's choice of protective coating system on parking decks has been developed, starting in Stage III of this project. The tool is based on:

- building construction of the current parking deck
- existing environment
- the client's needs and preferences

Instructions and the various possible choices are given in an Excel sheet. The client fills in and gets suggestions on appropriate product choices. A more detailed description can be found in Appendix B of the SBUF report 13212 (in Swedish).

The tool will be tested and evaluated tentatively in practice during 2017, and will then be made available to selected websites free of charge.

3 Conclusions

Conclusions from stages I to IV are summarized below.

3.1 Test fields, testing of wear resistance and guidelines

Test fields were placed within stages I to III in three different garages in Gothenburg, Stockholm and Linköping. Placing of the different test areas was successful in all cases without major problems and was completed within the deadline (November 2013, August 2014 and July 2015). Test areas were inspected visually, mainly for wear. Test slabs were applied for testing wear resistance in the laboratory. Laboratory testing was carried out in 2014 (in Stage II) and 2015 (in Stage III).

Testing according to Resistance to scuffing was performed for a total of 22 different coating systems. The systems had been applied to concrete slabs adjacent to the test-installations. Two test slabs were included for each coating system. Conclusions regarding the method so far in the project are:

- the correlation between individual test slabs seems good, but the repeatability or reproducibility has not yet been fixed for the current method
- a test period of 60 minutes is proposed, which means 2460 wheel revolutions with studded tyres at a rate of about 1 km / h in the laboratory
- the wear of the studded tyres (used in the test equipment) seems low and is not expected to have affected the test results significantly
- the method differentiates clearly between the various products and shows large differences
- method correlation to real wear on parking decks need to be verified by follow-ups of the current test fields for a number of years

When looking at the corresponding test results according to Prall, SS EN 12697-16, it can be stated that these results also differ widely. The two methods do not correlate with each other.

Testing according to RWA was performed for the coating systems in Kville and Åkeshov but was not included in the third test round due to poor repeatability of the method and lack of compliance with experience in the field.

Guidelines for waterproofing and protection coating systems to be used on concrete parking decks have been developed together with a support tool for the client's choice of protective coating system on parking decks. Both guidelines and support tool now need to be used and validated.

4 Continuation

The good work now needs to continue with follow-ups of test fields with coating systems since 2013. The obtained results have to be launched and marketed, be of practical use and evaluated over time. This is listed below:

- Continued inspections of coating systems in Kville, Åkeshov and Baggen.
  Follow-ups are needed to correlate the laboratory test results with real wear in the field so that the appropriate level of requirements for wear resistance caused by studded tyres can finally be set. Documentation.

- Use and evaluation of guidelines and the support tool that will lead to improvements and revised versions of these documents. These will lead to increased knowledge, satisfied clients and more sustainable facilities for the future.

- Continuing dissemination of information.

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